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Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

START

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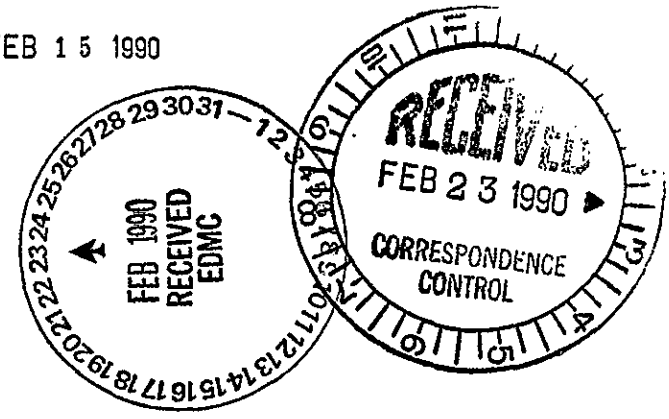

Mr. Robert R. Mooney, Head
Environmental Radiation Section
Department of Health
Mail Stop LE-13
Olympia, Washington 98504-0095

Dear Mr. Mooney:

APPLICATION FOR APPROVAL OF MODIFICATION

The enclosure serves as an Application for Approval of Modification for the Grout Treatment Facility (GTF), pursuant to Washington Administrative Code (WAC) 402-80-070. The GTF is located within the 200 East Area of the Hanford Site.

On November 28, 1986, the U. S. Environmental Protection Agency (EPA), Region 10, approved the construction of the GTF (at that time identified as the Transportable Grout Facility) and up to 75 disposal vaults at the Hanford Site, in response to the submission of an "Application for Approval of Construction," pursuant to 40 CFR, Section 61.07.

Radionuclide emission estimates developed for the original application for the GTF were based upon the proposed facility design and the radionuclide source term of phosphate/sulfate wastes from N Reactor operations, and other tank wastes, including double-shell tank wastes. Subsequent to EPA construction approval, changes to the vent system design concept were proposed which would increase the exhaust airflow and result in total offsite dose of 0.0024 mrem/year to the maximally exposed individual. WAC 402-80-50 limits such exposure to 25 mrem/year to the whole body, and 75 mrem/year to the critical organs, which are 10,415 and 31,215 times higher than the proposed emission from GTF, respectively. Paragraph 7.1 of the enclosure evaluated control measures which were considered for reduction of total emissions from the Grout Vaults.

By incorporation of Section 40 CFR 61.07, WAC 402-80-070 states that pre-construction approval is required for any new or modified source of radioactive emissions to the atmosphere. A modified source is defined as any source from which emissions are increased.

This application is being submitted to reflect the proposed design changes that will bring about an increased radionuclide emissions rate of radionuclides from the disposal vaults.

Should you have questions regarding the enclosed application, please contact Mr. A. J. Knepp, of my staff, on (509) 376-1471, or Mr. M. Dev, Waste Management Division, on (509) 376-3412.

Sincerely,

R. D. Izatt, Director
Environmental Restoration Division
Richland Operations Office

WMD:MD

R. E. Lerch, Manager
Environmental Division
Westinghouse Hanford Company

Enclosure

cc w/encl:
[redacted]

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Author	Addressee	Correspondence No.
J. J. Luke, 376-8629	Robert R. Mooney, Department of Health	Incoming # 9000814

Subject

APPLICATION FOR APPROVAL OF MODIFICATION

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DEPARTMENT OF HEALTH
APPLICATION FOR APPROVAL OF MODIFICATION
FOR THE GROUT TREATMENT FACILITY
INTRODUCTION

The following application for approval of modification is being submitted by the U.S. Department of Energy-Richland Operations Office (DOE-RL, P.O. Box 550, Richland, Washington, 99352) pursuant to WAC 402-80-070, for the Grout Treatment Facility (GTF). The GTF is located within the 200 East Area of the Hanford Site, as shown in Figure 1.

On November 28, 1986, the U.S. Environmental Protection Agency (EPA), Region 10, approved the construction of the GTF and up to 75 disposal vaults (at that time identified as the Transportable Grout Facility) at the Hanford Site (Figure 2) in response to the submission of an "Application for Approval of Construction", pursuant to 40 CFR, Section 61.07.

The grout process involves mixing low-level liquid radioactive wastes with a blend of nonradioactive dry material (Portland cement, flyash, blast furnace slag, and ground limestone or a similar diluent) and pumping the resulting grout slurry to preconstructed concrete vaults for disposal in a manner that will ensure isolation of the waste from man and the biosphere without the need for long-term maintenance. This process, however, results in the release of small quantities of airborne radioactive material.

Radionuclide emissions estimates developed for the original 40 CFR, Section 61.07 application for the GTF were based upon the proposed facility design and the radionuclide source term of phosphate/sulfate wastes from N Reactor operations and other tank wastes including double-shell tank (DST) wastes. Subsequent to EPA construction approval, changes to the vent system design concept were proposed which would increase the exhaust airflow and result in a radionuclide emissions increase of approximately 224 Ci/year (from 9 Ci/year to 233 Ci/year). It should be noted that this projected emissions increase provides an offsite dose of 0.0024 mrem/year to the maximally exposed individual, which is well below the WAC 402-80-50 limits for the maximally exposed individual of 25 mrem to the whole body and 75 mrem to the critical organ.

This application is being submitted to reflect the proposed design change that will bring about the increased emissions rate from the disposal vaults. The disposal vault ventilation system, therefore, constitutes the modification to be examined by this application.

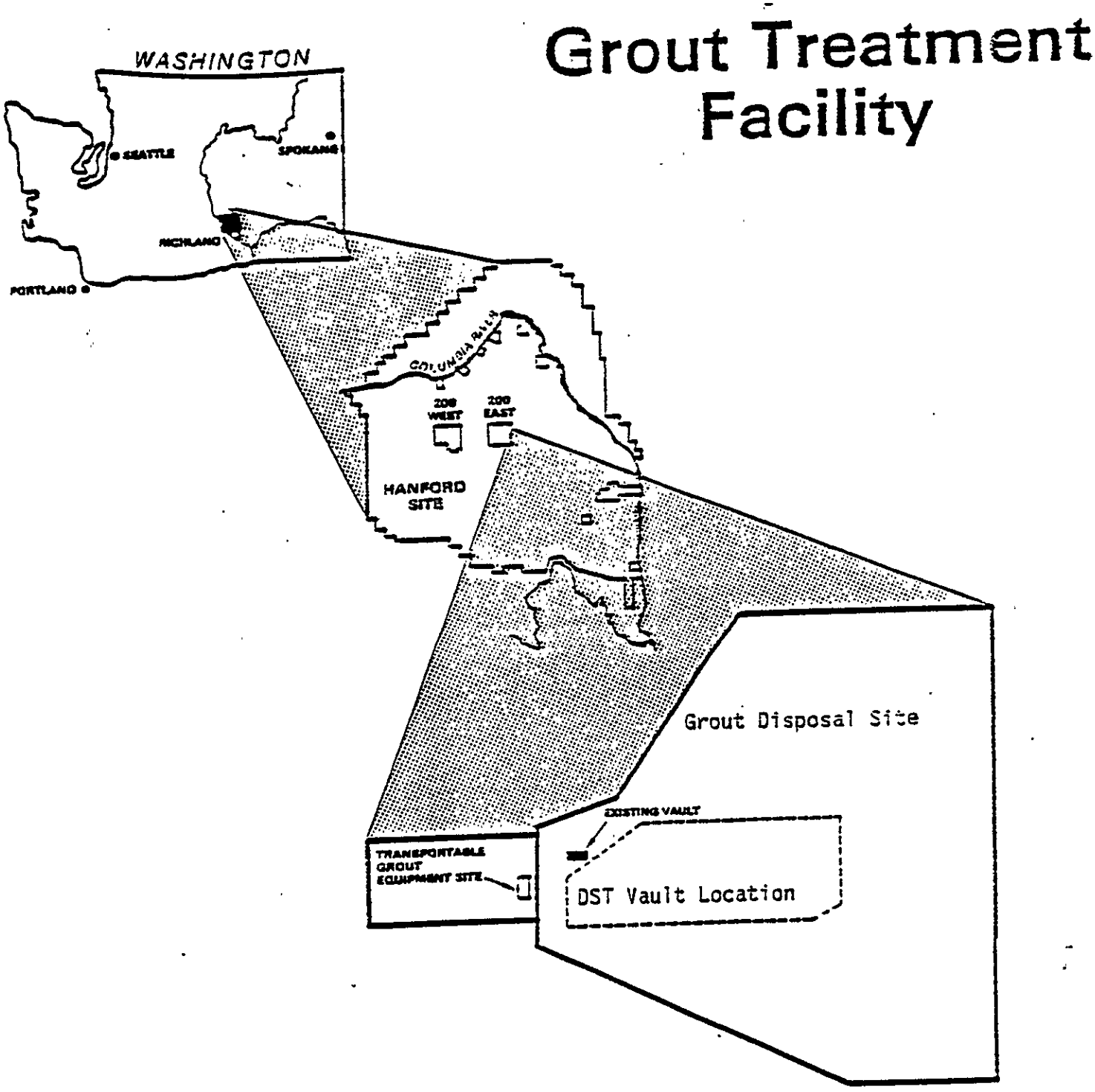

Figure 1. Location of Grout Treatment Facility

GROUT TREATMENT FACILITY
SITE PLAN

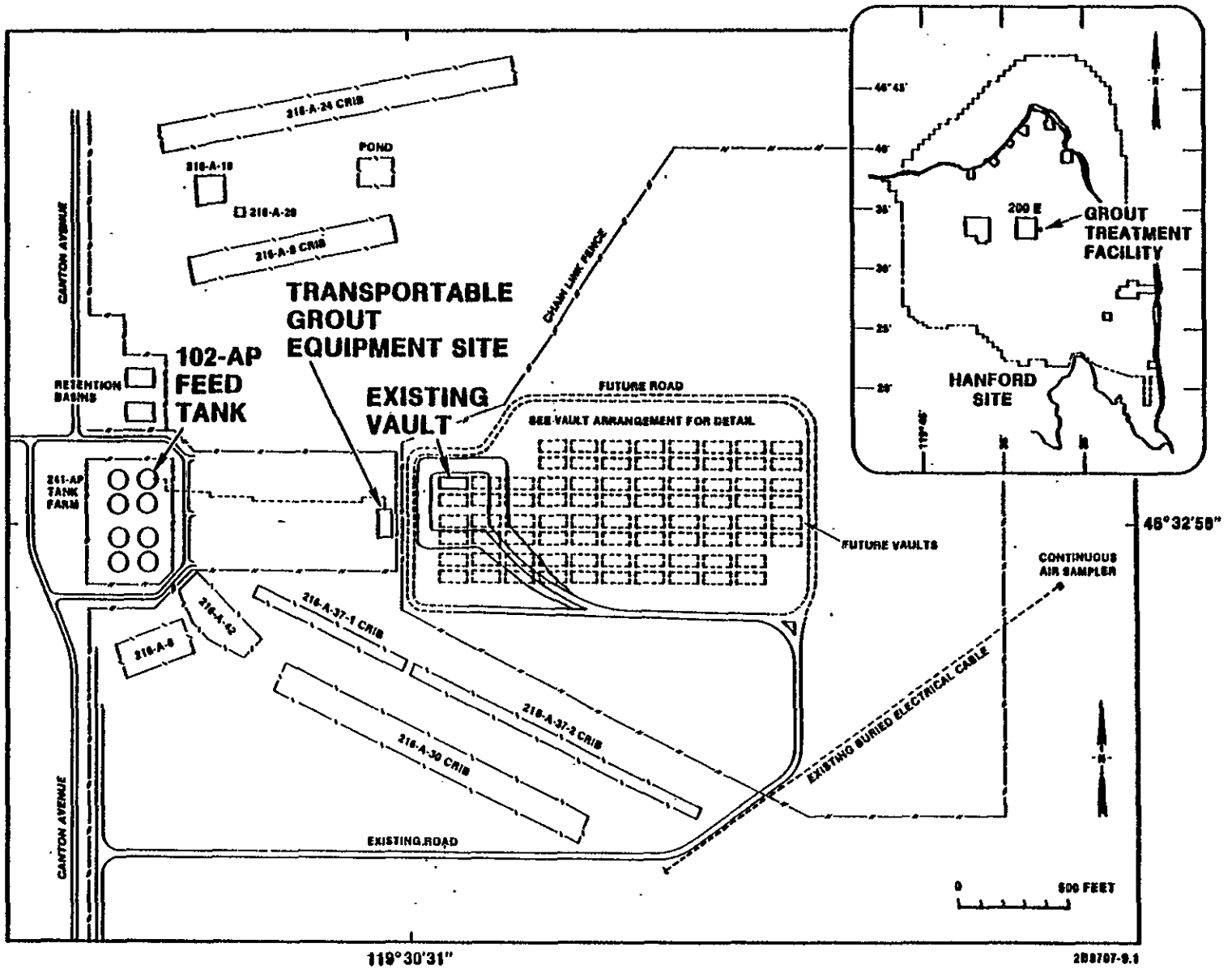

Figure 2. GTF as Permitted by the EPA on November 28, 1986

DEPARTMENT OF HEALTH
APPLICATION FOR APPROVAL OF MODIFICATION
GROUT TREATMENT FACILITY

1.0 PROPOSED NATURE OF THE SOURCE

The GTF is a treatment and disposal facility for liquid low-level radioactive waste. The GTF was approved for construction by the U.S. Environmental Protection Agency, Region 10, on November 28, 1986. The GTF immobilizes the liquid waste in cement-based grout for disposal in near-surface vaults designed to comply with the requirements of the Resource Conservation and Recovery Act. The subject modification is proposed for the disposal vaults. Therefore, the disposal vaults constitute the modification to be examined by this application.

2.0 PROPOSED SIZE OF THE SOURCE

The disposal vaults will be located in the near-surface disposal site (NSDS), an area of approximately 718,000 square yards in the 200 East Area (Figure 1). The NSDS will contain approximately 44 disposal vaults. (The original Application to Construct was approved for the construction of 75 disposal vaults.) Each vault will have a rectangular cross-section with inside dimensions approximately 125 ft long, 50 ft wide, and 34 ft deep. The top of the grout will be a minimum of 16 ft 5 in below grade. (See Figure 3.)

3.0 PROPOSED DESIGN OF THE SOURCE

The grout disposal vaults will be constructed of cast-in-place reinforced concrete with an inside surface of asphalt, which serves as an elastic waterproofing material. Approximately 2,400 cubic yards of concrete is used in the construction of each vault (foundation, walls, and floor). The concrete, which has a minimum 28-day compressive strength of 4,500 psi, is made of low-alkali portland cement. Approximately 320,000 pounds of steel reinforcing is added to the structure to meet performance standards.

The roof of the vault is made of 31 prestressed cover blocks. Each cover block is approximately 4 feet wide, 52.5 feet long, and 26 inches thick. Gaps between adjacent cover blocks are filled with cement grout.

A total of 52 penetrations through the cover are provided to perform service functions during grout operations. The following list provides a description and purpose of each penetration.

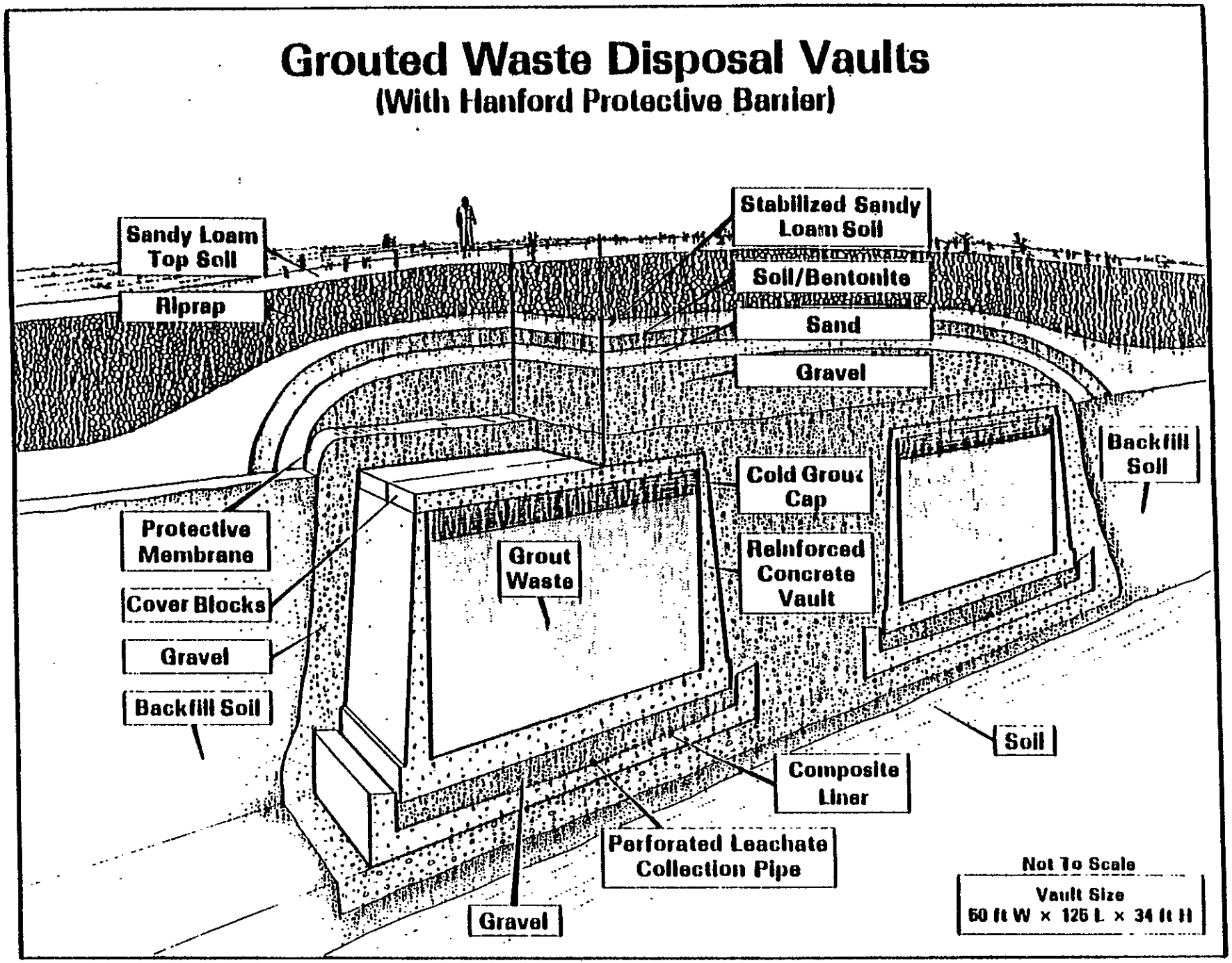

Figure 3. Grouted Waste Disposal Vault

Purpose	Number	Size (in.)
Grout discharge pipe	1	4
Thermocouple tree	4	1.5
Grout level element	4	4
Vault pressure element	1	2
Vault exhausters	2	18
CCTV access	2	10 x 14
Excess water removal (pit drain)	5	3
Excess water removal (pump)	4	12
Nonradioactive void-fill injection ports	29	4

The previously approved design for vault ventilation during the fill and cure process was based on displacement. That is, exhaust air flow from the vault was a function of the grout fill rate. The grout fill rate has been in the range of 30 to 70 gallons per minute, which, in turn, has produced an exhaust rate of up to 10 cfm. The proposed design change which constitutes the basis for this application calls for the use of forced exhaust. Forced exhaust has been incorporated into the disposal vault ventilation system to control temperatures and to provide containment during operations, maintenance, and sampling. The projected exhaust flow rate will be in the range of 0 to 3,600 actual cubic feet per minute (acfm). Figure 4 shows the conceptual design for the exhauster under consideration at this time.

4.0 OPERATING DESIGN CAPACITY

A nominal grout campaign is expected to process one million gallons of liquid waste feed, produce 1.4 million gallons of grout, and fill one disposal vault. The Transportable Grout Equipment (TGE) will produce grout at a rate of approximately 30-70 gallons per minute. Dry materials used in the grout formulation will be blended at a rate of 6.8 to 14.0 tons/hr.

A nominal campaign duration is expected to be 30 days at 50% of capacity, excluding feed preparation and staging requirements. The expected operational mode will be 24 hours per day, 5 days per week. It is anticipated that approximately 44 million gallons of low-level waste will be processed through the GTF, producing approximately 63 million gallons of grout slurry, and filling approximately 44 disposal vaults. Construction and waste feed preparation constraints limit operating capacity to filling no more than four disposal vaults per year, the calculational basis for emissions modeling.

5.0 METHOD OF OPERATION

The disposal process involves mixing of low-level radioactive wastes with a blend of cementitious materials (Portland cement, flyash, blast furnace slag, and ground limestone or a similar diluent) and pumping the resulting grout slurry to preconstructed concrete vaults. (Figure 5 is a simplified overview of this process.) This is defined as the active fill phase and is anticipated to take approximately 30 days per vault.

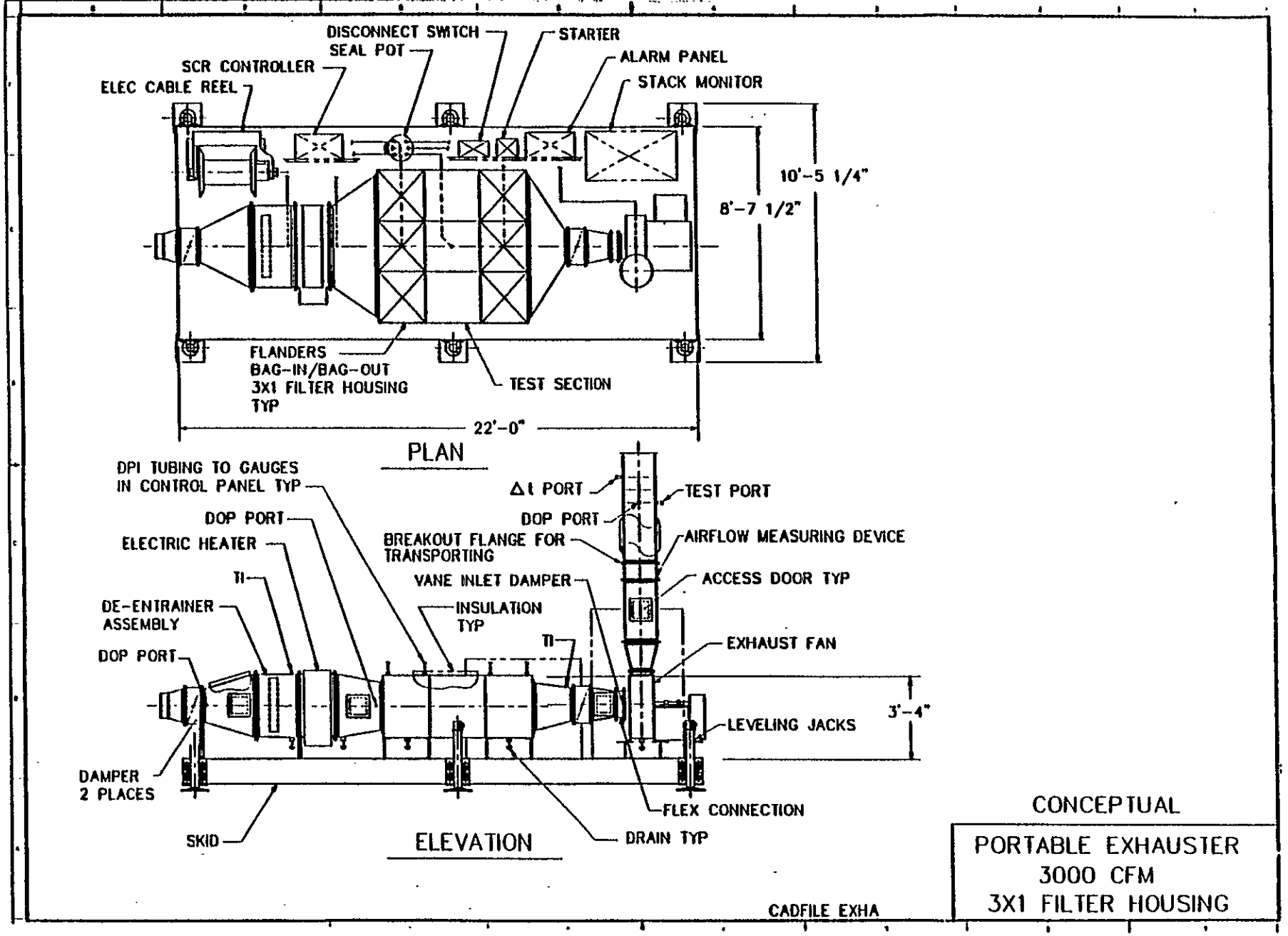

Figure 4. Conceptual design for Portable Exhauster

GROUT FACILITIES

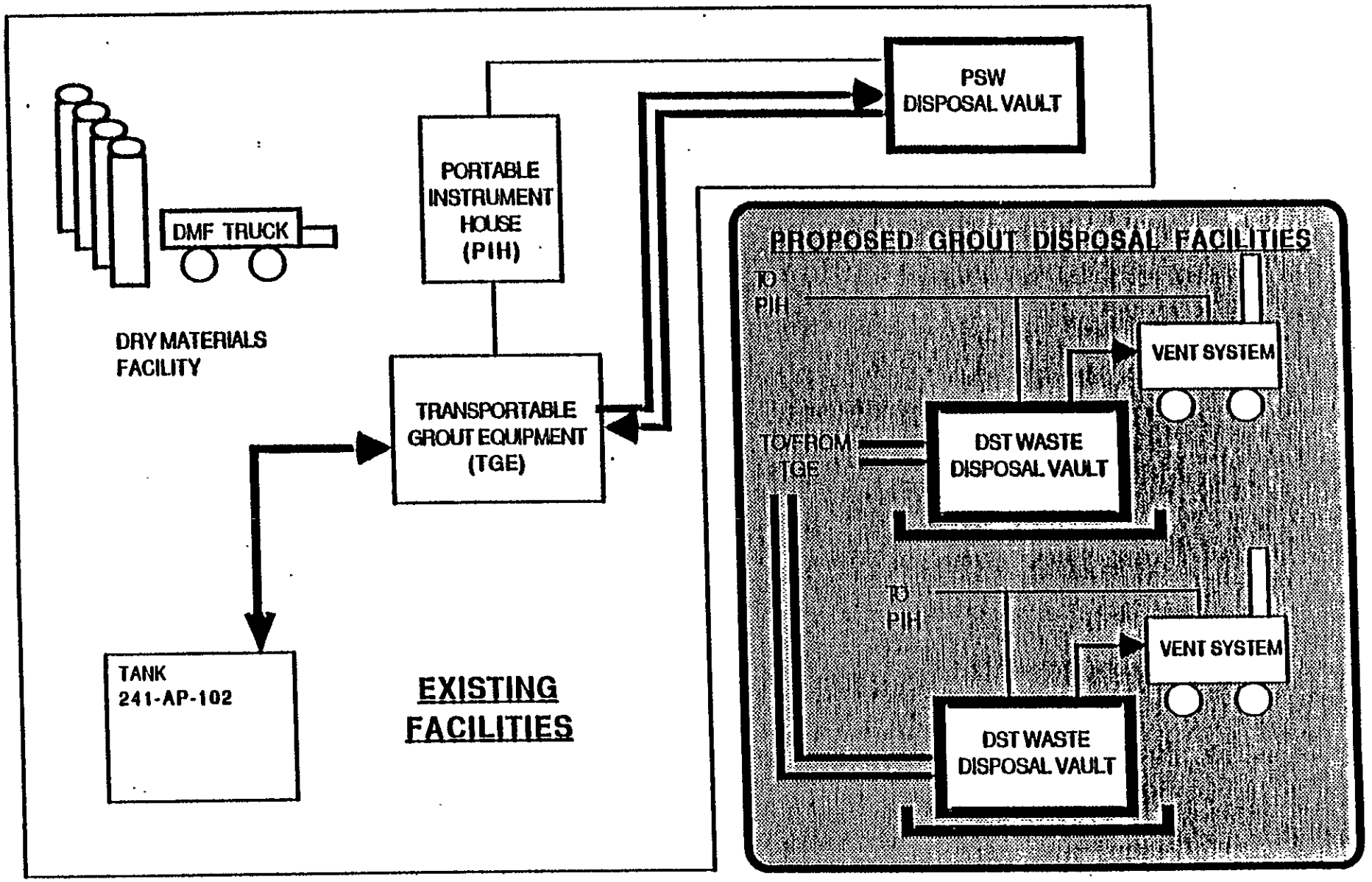

Figure 5. GTF Simplified Process Flow Diagram

The grout slurry will then cure and solidify to immobilize the wastes within the grout matrix. This is defined as the stagnant operation phase. Up to 180 days of stagnant operation are anticipated prior to void filling a disposal vault. After the grout has hardened, any remaining liquid will be returned to the double-shell tank system and the space above the solidified waste will be void filled with nonradioactive grout to seal the radioactive grout and to prevent subsidence. The vault will then be covered with an additional protective barrier to inhibit water infiltration or plant, animal, and human intrusion into the waste zone.

6.0 EMISSIONS CONTROL SYSTEM

Filtration of the exhaust air, varying from 0 to 3600 acfm, will be accomplished by primary and secondary filtration stages comprised of self-contained HEPA filters. Figure 6 represents the current conceptual design of the ventilation system. The stack will be provided with a stack sampler which will monitor and record the level of radionuclide emissions. An isokinetic probe will extract air from the stack, routing it to the stack sampler/monitor.

While the grout is curing, a pool of liquid will form on top of the grout. Heat from the curing grout will raise the temperature of the liquid and consequently the air above it. It is also assumed, for the purposes of emissions analyses, that the air will be saturated, that is, it will be at 100% relative humidity.

6.1 EMISSION RELEASE RATES

The controlled release rates of particulate radionuclides from the GTF were calculated using the following formulas (^{137}Cs as an example):

- E_i (Ci/day) = C_i (Ci/l feed) x (l feed/1.43 l grout) x PF x (28.316 l/ft^3) x VR (ft^3/min) x (1440 min/day)/DF

- TGE Stack
  $E_{^{137}Cs}$ = 3.7E-01 x (1/1.43) x 2.49E-09 x 28.316 x 710 x 1440/4E+06
  = 4.66E-09 Ci/day

- Active Vault
  $E_{^{137}Cs}$ = 3.7E-01 x (1/1.43) x 2.87E-10 x 28.316 x 3600 x 1440/4E+05 = 2.73E-08 Ci/day

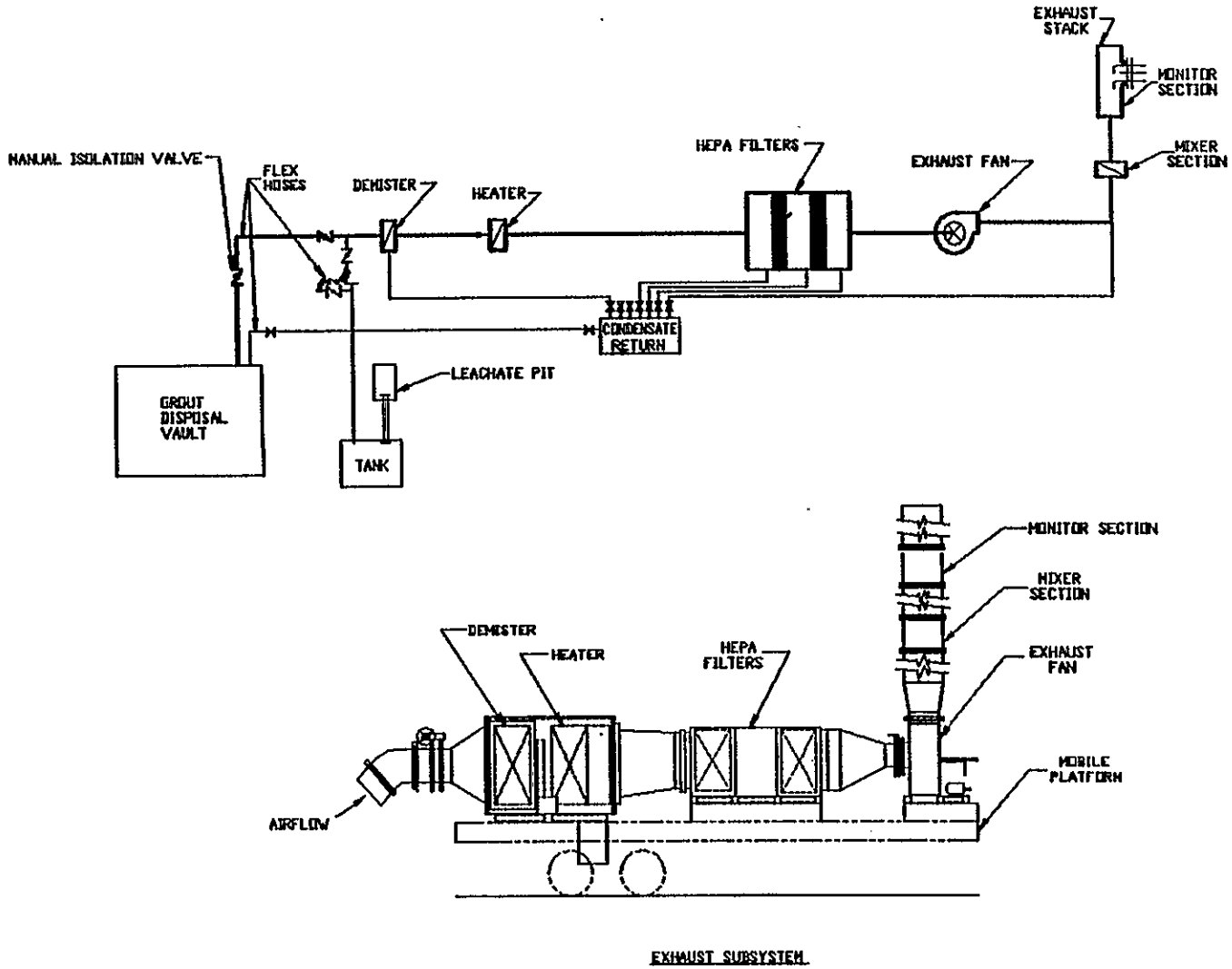

Figure 6. Conceptual Grout Disposal Vault Exhaust System

- Stagnant Vault
  $E_{^{137}Cs}$ = 3.7E-01 x (1/1.43) x 1.72E-11 x 28.316 x 3600 x 1440/4E+05 = 1.63E-09 Ci/day

- $E_{i,tot}$ (Ci) = $(E_i \times t)_{TGE} + (E_i \times t)_{Act} + (E_i \times t)_{Stg}$ = (4.70E-09 x 30) + (2.73E-08 x 30) + (1.63E-09 x 180) = 1.25E-06 Ci/campaign

Where:

- Vapor Temperature

  The temperature of the exhausted vapor, in the range considered, is important only in consideration of tritium emissions. That is, tritium is assumed to be emitted in the form of water vapor with a vapor space concentration of 100% relative humidity at an assumed temperature of 120°F. Under these conditions, the tritium partition fraction is that which is discussed below.

- PF = Vapor/Grout Partition Fraction

  Emission rates of radionuclides are dependant upon the distribution of the radionuclide between the vapor space and grout slurry. Conservative PFs and their application were derived from the characterization of mixed, actively filling, and stagnant tank vapor space and slurry concentrations. In application, it is deemed that the vapor space concentrations of radionuclides are equal to the grouted concentration of a radionuclide multiplied by the partition fraction appropriate to the operation and radionuclide. Partition fractions for tritium are 1.17E-04 for all operations. Partition fractions for other radionuclides are 2.87E-10 from the active vaults, 2.49E-09 for the TGE, and 1.72E-11 during stagnant operation. Conservatively, the resultant vapor space concentration is assumed to remain unaffected by ventilation in each of the three operations.

- VR = Ventilation Rate

  The portable exhauster design for the grout vaults calls for exhaust rates of 0 to 3,000 acfm with a rated maximum of 3,600 acfm. The VRs are thus applied in emission calculations as 3,600 acfm from either active or stagnant vault operations and 710 acfm from the TGE stack.

- DF = Decontamination Factor

  A DF is the inverse of one minus the efficiency of control of a control device. Thus, a 90% efficiency of control is represented by a DF of 10, and 99.95% by a DF of 2,000. Decontamination factors used in these calculations are 2,000 for the first HEPA filter, 200 for a second sequential HEPA filter, and 10 for a fabric filter. The vaults are

controlled by dual HEPA filters with a total DF of 400,000, while the TGE stack is controlled by dual HEPA filters following a fabric filter for a total DF of 4,000,000.

NOTE: Tritium, the dominant dose commitment contributor, is not controlled by either of these devices, since tritium is emitted from the GTF in the form of water vapor. Tritium emissions are calculated upon the assumption that the gases leaving the vaults and TGE contain water vapor at 100% of the relative humidity of the gases at the maximum anticipated gas temperature and flow rate. Hence, the DF for tritium is 1 for all operations.

- t = Duration of Emissions

  The duration of emissions from any given campaign is applied as the time (t) during which that operation exhausts a radionuclide bearing airstream. It is assumed that active vault and TGE operations duration are identical at 30 days. It is further assumed that stagnant vault operations will last 180 days until grout-cap placement. (This is an extremely conservative assumption in regard to time of emissions, since the free water that pools on top of the grout should have evaporated within the first 30 days, and it is the free water that constitutes the source of tritium emissions.) The air partition fractions are assumed constant and independent of time given the operation.

- C_i = Component Feed Concentration

  The concentration of individual radionuclide feed components and their radioactive daughters are expressed in Curies per liter of feed (Ci/l feed). The concentrations are based upon chemical and radiological analyses of the composition of three representative waste feed tanks and upon dilution factors necessary to maintain the radiolytic heat contributions of ^{137}Cs and ^{90}Sr within the design specifications of each grout vault.

Table 1, following page, shows the currently projected controlled emissions from the GTF for one year (4 campaigns). Table 2 presents a comparison of the "Total" emission rates listed in Table 1 with the emission rates provided in the original construction approval request submitted to the EPA on July 29, 1986.

TABLE 1. GTF Radionuclide Emissions
Basis: Four Campaigns Per Year

Radio-isotopes	Active Vaults (Ci/year)	Stagnant Vaults (Ci/year)	TGE Stack (Ci/year)	Total Emissions (Ci/year)
^{3}H	$3.24 \times 10^{+1}$	$1.95 \times 10^{+2}$	$6.40 \times 10^{+0}$	$2.33 \times 10^{+2}$
^{14}C	9.81×10^{-12}	3.53×10^{-12}	1.68×10^{-12}	1.50×10^{-11}
^{60}Co	2.45×10^{-10}	8.80×10^{-11}	4.19×10^{-11}	3.75×10^{-10}
^{79}Se	2.23×10^{-10}	8.02×10^{-11}	3.82×10^{-11}	3.41×10^{-10}
^{90}Sr	9.86×10^{-8}	3.54×10^{-8}	1.69×10^{-8}	1.51×10^{-7}
^{90}Y	9.86×10^{-8}	3.54×10^{-8}	1.69×10^{-8}	1.51×10^{-7}
^{94}Nb	3.12×10^{-10}	1.12×10^{-10}	5.34×10^{-11}	4.77×10^{-10}
^{99}Tc	7.89×10^{-10}	2.84×10^{-10}	1.35×10^{-10}	1.21×10^{-9}
^{106}Ru	1.48×10^{-7}	5.33×10^{-8}	2.54×10^{-8}	2.27×10^{-7}
^{106}Rh	1.48×10^{-7}	5.33×10^{-8}	2.54×10^{-8}	2.27×10^{-7}
^{129}I	2.68×10^{-12}	9.63×10^{-13}	4.58×10^{-13}	4.10×10^{-12}
^{134}Cs	4.19×10^{-8}	1.51×10^{-8}	7.17×10^{-9}	6.41×10^{-8}
^{137}Cs	3.26×10^{-6}	1.17×10^{-6}	5.58×10^{-7}	4.99×10^{-6}
^{137m}Ba	3.05×10^{-6}	1.10×10^{-6}	5.22×10^{-7}	4.67×10^{-6}
^{234}U	2.85×10^{-13}	1.02×10^{-13}	4.87×10^{-14}	4.36×10^{-13}
^{235}U	1.84×10^{-14}	6.62×10^{-15}	3.15×10^{-15}	2.82×10^{-14}
^{238}U	1.41×10^{-13}	5.07×10^{-14}	2.41×10^{-14}	2.16×10^{-13}
^{237}Np	1.82×10^{-12}	6.56×10^{-13}	3.12×10^{-13}	2.79×10^{-12}
^{238}Pu	7.08×10^{-12}	2.55×10^{-12}	1.21×10^{-12}	1.08×10^{-11}
$^{239}Pu/^{240}Pu$	1.53×10^{-11}	5.49×10^{-12}	2.61×10^{-12}	2.33×10^{-11}
^{241}Am	1.76×10^{-11}	6.32×10^{-12}	3.01×10^{-12}	2.69×10^{-11}
^{244}Cm	2.16×10^{-12}	7.75×10^{-13}	3.69×10^{-13}	3.30×10^{-12}
Total	$3.24 \times 10^{+1}$	$1.95 \times 10^{+2}$	$6.40 \times 10^{+0}$	$2.33 \times 10^{+2}$

TABLE 2. GTF Total Radionuclide Emission Rates
Comparison of Projected to Previously Approved Emissions
Basis: Four Campaigns Per Year

Radio-isotopes	Previously Approved Emissions (Ci/year)	Projected Emissions (Ci/year)
^{3}H	$8.74 \times 10^{+0}$	$2.33 \times 10^{+2}$
^{14}C	2.30×10^{-12}	1.50×10^{-11}
^{60}Co		3.75×10^{-10}
^{79}Se		3.41×10^{-10}
^{90}Sr	4.60×10^{-8}	1.51×10^{-7}
^{90}Y		1.51×10^{-7}
^{93}Zr	2.30×10^{-12}	
^{95}Zr	9.14×10^{-14}	
^{94}Nb		4.77×10^{-10}
^{99}Tc	2.07×10^{-11}	1.21×10^{-9}
^{106}Ru	4.60×10^{-8}	2.27×10^{-7}
^{106}Rh		2.27×10^{-7}
^{129}I	4.60×10^{-14}	4.10×10^{-12}
^{134}Cs		6.41×10^{-8}
^{137}Cs	1.15×10^{-8}	4.99×10^{-6}
^{137m}Ba		4.67×10^{-6}
^{151}Sm	4.60×10^{-10}	
^{234}U		4.36×10^{-13}
^{235}U		2.82×10^{-14}
^{238}U		2.16×10^{-13}
^{237}Np		2.79×10^{-12}
^{238}Pu		1.08×10^{-11}
$^{239}Pu/^{240}Pu$	4.60×10^{-13}	2.33×10^{-11}
^{241}Am	4.60×10^{-11}	2.69×10^{-11}
^{244}Cm		3.30×10^{-12}
Total	$8.74 \times 10^{+0}$	$2.33 \times 10^{+2}$

6.2 OFFSITE DOSES

The AIRDOS-EPA (Clean Air Act Code) computer code (Oak Ridge National Laboratory, 1987) was used to calculate the dose commitment from the GTF to the maximally exposed offsite individual to demonstrate compliance of the proposed facility modification with radiological emission standards of the EPA. Doses for three emission streams: the TGE stack; grout vaults in stagnant operation (Section 5.0); and grout vaults in active operation (Section 5.0) were developed using the data from Table 1 and input into the code as the source term. The maximum offsite exposure location was approximately 24 km SE of the 200 Area of the Hanford Site.

Meteorological data input to the AIRDOS-EPA code include mixing height, rainfall rate, average air temperature, vertical temperature gradient, wind direction frequency, wind speed, and atmospheric stability. This information was obtained from the data base compiled by the Hanford Meteorological Station (HMS). HMS data on wind speed, direction, and temperature are collected at a 410-ft tower located on the Hanford Site between the 200 East and 200 West Areas. Wind speed and direction are based on hourly data collected at the 200 Area meteorological tower 10-meter level during the years 1983-1987. Atmospheric stability was estimated from the temperature gradient between the 30-ft and 200-ft levels at the HMS for the same period using standard methods of the U.S. Nuclear Regulatory Commission. Air temperature and mixing height are also 5-year averages of hourly data. Temperature is measured at the tower 200-ft level, and mixing height data are collected by onsite acoustic sounders.

Joint frequency data, as reported by the HMS, are modified for input into AIRDOS by conversion to true average and reciprocal average wind speeds for each direction and stability class. The meteorological data are then used to calculate Chi\Q values for each radionuclide, which are also a function of radiological half-life and dry deposition velocity. For purposes of this calculation, deposition velocities are assigned as follows: 1.0 E-3 m/s for all particulate materials, 1.0 E-2 for iodine isotopes, and 0 for all gaseous components.

Results

Maximum individual doses for the GTF, as shown in Table 3, following page, were less than 0.01 mrem. Virtually all of the dose was due to tritium. Ingestion was the dominant pathway with a smaller contribution from inhalation. The organ receiving the largest dose was the intestinal wall; however, the dose to all organs was relatively uniform.

Ambient air quality standards and emission limits for radionuclides within Washington State have been promulgated by the Department of Ecology in WAC 173-480. That standard requires that emissions of radionuclides to the air shall not cause a dose equivalent of more than 25 mrem/year to the whole body or 75 mrem/year to a critical organ of any member of the public.

A comparison of the data presented in Table 3, with the cited statutory limits, shows that the projected "whole body" and "critical organ" doses of airborne radionuclides from the GTF to the maximally exposed off-site individual would not violate WAC 173-480 standards.

Further, the Effective Dose Equivalent (Whole Body Dose) to the maximally exposed off-site individual from all Hanford Site operations air emissions was 0.3 mrem in 1988 (Jacquish). If the projected whole body dose from the GTF, as listed in Table 3, is added to the historic releases for 1988, it is clear that the projected emissions from the GTF modification will not cause a violation of WAC 173-480 standards.

TABLE 3. Dose Estimates for an Individual Receiving Maximum Exposure to Radiological Emissions from the GTF (location 24 km SE)
Basis: Four Campaigns Per Year

70-Year Committed Dose From One Year of Operation
(effective dose equivalent, mrem)

Facility:	Active Vaults	Stagnant Vaults	TGE Stack	Total Dose
Whole Body:	3.3×10^{-4}	2.0×10^{-3}	7.0×10^{-5}	2.4×10^{-3}
Critical Organ:				
Intestine Wall	3.3×10^{-4}	2.0×10^{-3}	7.0×10^{-5}	2.4×10^{-3}
Percent of Whole Body Dose				
Critical Pathway:				
Ingestion (%):	85	85	85	
Inhalation (%):	15	15	15	
External (%):	0	0	0	
Critical Radionuclide:				
^{3}H	100%	100%	100%	

NOTE: For the purpose of comparison with the dose commitment information provided above, 3.3×10^{-5} mrem was the original projected whole body dose commitment from the GTF, to the maximally exposed individual, provided to the EPA in the July 29, 1986 construction approval request.

7.0 A Demonstration of Best Available Radionuclide Control Technology (BARCT) Selection

A BARCT is defined by WAC-402-80-40 as follows:

> Technology which will result in a radionuclide emission limitation based on the maximum degree of reduction for radionuclides which would be emitted from any proposed stationary source or modification of a source which the permitting authority on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such source or modification through application of production processes or available methods, systems, and techniques. In no event shall application of best available radionuclide technology result in emissions of radionuclides which would exceed the ambient annual standard limitation specified in this chapter.

The selection of the emissions control system described in Section 6.0 is supported as BARCT for the pollutants to be emitted by the GTF by the following.

7.1 Control Alternatives

Potential radioactive emissions from the disposal vaults will consist primarily of particulates and tritium. In this section alternatives for controlling these two pollutants are identified. In order to identify all possible emission controls for this process, a nuclear and cross-industry survey for particulate matter and tritium controls was conducted. Control alternatives that were considered in the survey included gas cleaning equipment, the application of production processes, and any other systems, techniques, or methods that would reduce emissions to the atmosphere. Documents reviewed in the survey are listed in Appendix A. All of the controls identified have been previously applied in radiochemical processing operations.

7.1.1 Particulate Control Techniques Available

Because of the composition of the grout and its physical characteristics (including its aqueous state), suspended particulate matter is anticipated to be in the micron and submicron size range. Therefore, devices capable of collecting only large diameter particles (cyclones and other mechanical collectors) were not considered in the survey. Potentially applicable particulate matter controls identified in the survey, with detailed process descriptions and evaluations, are summarized in Appendix B.

7.1.2 Tritium Control Techniques Available

No demonstrated methods for controlling tritium emissions from a grout disposal operation were identified. The techniques discussed in this section have been demonstrated on other processes and the technology is potentially

transferable. Tritium will be emitted by the disposal vaults as tritiated water. Devices or methods that are only applicable to other chemical forms of tritium are not included. Potentially applicable tritium controls identified in the survey, with detailed process descriptions and evaluations, are summarized in Appendix B.

Three techniques for controlling tritium have been identified. Two of these techniques, adsorption and condensation, were found in the literature. Each of these techniques utilizes add-on devices that would remove tritium from the exhaust gas. The definition of BARCT, however, is not limited to gas cleaning methods or add-on devices. It also allows consideration of the "application of production processes." The third technique, infiltration control, is such an application.

7.1.3 Control System Alternatives

In this section, the particulate and tritium control techniques identified in the previous sections are evaluated to determine whether they can be applied to the disposal vaults. Those techniques determined to be applicable to the disposal vaults are then considered as potential control systems, and as candidates for BARCT.

The information collected on control methods usually describes only their capabilities for a single pollutant. Unless otherwise stated, it is assumed in developing combined particulate/tritium control systems that there is no incompatibility nor will there be synergism (regarding control efficiencies) when these methods are combined to form a system.

Final, high-efficiency particle filtration before discharge of radionuclide-contaminated gases to the atmosphere is a nuclear industry standard. Generally, two-stage filtration is utilized for this purpose. Therefore, all exhaust from the disposal vaults will be routed to a particulate matter filtration step prior to discharge to the atmosphere.

The potential applicability of some particulate matter control techniques is affected by the need for the control system to be mobile. Vault locations are spread over a large area (Section 2.0). The location of the emission source will change as various vaults are placed in operation and others are closed. A mobile (trailer mounted) ventilation system, which includes the control equipment, will be used during vault filling, curing, and closure. After closure, the mobile ventilation system will be moved to the next vault. Mobile ventilation units are a well-developed technology in the nuclear industry.

The need for a mobile ventilation/control system precludes the use of deep bed glass fiber filters (DBGFF), high efficiency mist eliminators (HEMEs), or deep bed sand filters. With the exception of the HEME, these techniques require a large amount of space, and in the case of sand filters, great weight that could not reasonably be mobilized. Typical sand filters occupy 5.60 to 36.00 square feet with sand to a depth of 8 feet. This is

approximately 2,000 to 12,000 tons of sand. A typical DBGFF is 40 x 80 x 14 feet. A HEME requires plumbing for filter cleaning with a water-wash.

A stationary ventilation system that would accommodate these techniques could be used with temporary ducting connecting it to each vault. However, since these techniques do not represent the highest degree of particulate control available, this scenario offers no environmental benefits. In addition, the energy penalty associated with increased ducting lengths, and the increase in the risk of worker exposure makes this design impractical.

The control efficiency of an electrostatic precipitator (ESP) is highly dependent upon the characteristics of the exhaust gases. The disposal vaults will handle waste streams that will have some variability in composition; that variability will be present in the ventilation air. During different phases of the operation (filling, curing and closure), the ventilation air flow rate and air flow temperature will vary. This variability will result in inconsistent control efficiency performance for an ESP. It would also mandate frequent adjustments that would increase the risk of worker exposure, Thus, ESPs are not practical for this application.

The control efficiency of a baghouse or fabric filter is dependent to a large extent on the depth and composition of the particulate cake that forms on the fabric while the filter is in operation. Control efficiency is relatively low for a clean filter bag and increases as the filter cake builds. The low inlet particulate loadings will lengthen the period of time for adequate filter cake development, concurrently extending periods of low control efficiency for this technique. Therefore, baghouse filters are not well suited for this application.

The control efficiency of a HEME, at 99.5 for particles smaller than 3 microns is less than the HEPA at 99.97 for particles of 0.3 microns or larger. Additionally, as noted above, the HEME requires periodic backwashing which not only requires plumbing apparatus, but creates a secondary waste stream which, in turn, must be treated. Therefore, HEME filters are not well suited for this application.

HEPA filters offer a high level of particulate matter control during their entire service life. They are easily adapted to and have been demonstrated for use in mobile operations. Their control efficiency is not significantly effected by the composition of the gas stream, the flow rate, or its temperature, within reasonable limits. Of the potential particulate matter filters identified in Appendix B, only HEPA filters are amendable to the requirements of the disposal vaults.

Therefore, HEPA filtration is considered BARCT for particulate matter emissions from the disposal vaults and no further analysis of energy, environmental, or economic impacts is required because the control technology identified has been determined to be the technology that is both appropriate and allows the lowest emission rate of particulate radionuclides.

Tritium has been removed from exhaust gases by adsorption with molecular sieves and desiccants. Generally, these applications have involved relatively concentrated tritium releases and small volumes of non-tritiated water vapor. Adsorption is not applicable to the disposal vaults because of the low concentration of tritiated vapor and the large volume of non-tritiated liquid that would greatly increase the quantity of sieve or desiccant required.

Condensation could be used to remove tritium by removing a large proportion of the water vapor in the exhaust gas. This technique would utilize a chilled water cooler to reduce exhaust gas temperature and a condenser to collect and remove water that has condensed. This is a well-established technology that could be applied to the disposal vaults.

Infiltration control consists of design and operating practices that can be employed to minimize the leakage of air into the vault. One factor effecting the amount of tritium released from the vaults is the volume of ventilation air, which can be reduced by controlling infiltration with a well-designed and correctly installed concrete cover for the vault. Infiltration also can be controlled by installing an additional operating cover of asphalt-coated gravel and a protective membrane, which will further reduce air infiltration.

The tritium control techniques of infiltration control and condensation are both amenable to the requirements of the disposal vaults. Infiltration control as described above is an integral part of the vault design and operating practices, and represents a baseline tritium control level. Condensation, as an alternative tritium control technique, can be implemented as a control measure by the application of a chilled water cooling system and condenser for the exhaust gas placed upstream of the particulate control and the heater. Condensation would be used in addition to, not in lieu of, infiltration control.

Therefore, the tritium control systems which will be evaluated in the following BARCT analysis for the disposal vault exhaust are:

Two-stage HEPA/Infiltration Control
Two-stage HEPA/Infiltration Control/Condensation

7.1.4 BARCT Analysis

The following presents an evaluation of the final tritium emission control alternatives based on environmental, energy, and economic impacts to demonstrate BARCT for the disposal vault tritium emissions.

7.1.4.1 Environmental Impacts

The 70-year committed whole body dose to the maximally exposed off-site individual from one year of operation of the NSDS with baseline tritium controls was estimated at 0.0024 mrem/year (Section 6.2). This ambient impact

is insignificant when compared to air quality standards (Section 6.2) of 25 mrem to the whole body and 75 mrem to the critical organ. Further, it should be noted that the natural level of background radiation in the Tri-cities area is approximately 300 mrem/year (Jacquish, 1989). The projected annual dose from the NSDS would, then, constitute approximately 0.0008% of the annual dose from natural background sources.

Condensation would reduce ambient impacts to an even lower level. However, the net benefit to ambient air quality by moving from one insignificant level to another would be negligible.

The baseline alternative produces no solid or liquid waste. It has been estimated that condensation would produce up to 9.2 gallons per hour of tritiated water requiring disposal and handling, thus increasing the risk of worker exposure. Since condensation offers a negligible air quality benefit and potentially significant adverse waste disposal and worker exposure impacts, it is concluded that an environmental impact analysis favors the baseline control.

7.1.4.2 Energy Impacts

The power requirements for the ventilation system range from 63.5 to 71.0 kW for the baseline alternative. A condenser would require a 200-ton chilled water system, which would increase total power requirements to approximately 361 kw, more than a five-fold increase. The energy impacts analysis favors baseline control.

7.1.4.3 Economic Impacts

The lifecycle cost of using condensers for tritium control has been estimated as follows:

Chiller Cost (3 Units)	$525,000
Facility Modifications	$150,000
Electricity at Present Cost	$1,788,000
Maintenance at Present Labor Rates	$195,000
Lifecycle Cost of tritium Control:	$2,658,000

It has been demonstrated that a condenser system typically reduces tritium emissions by approximately 95% (Appendix B). In the case of the GTF, then, tritium emissions would be reduced from approximately 233 Ci/year to approximately 12 Ci/year.

Given the above, the lifecycle cost of using condensers for tritium control exceeds the cost of the baseline alternative by $2.658 million while providing a reduction in the off-site dose from 2.4 E-03 mrem/year (Section 6.2) to 1.2 E-04 mrem/year. This reduction would cost $1.16 billion per mrem. In addition, the condenser alternative will incur additional costs for handling and disposing of the large volume of tritiated water collected. The economic impacts analysis favors baseline control.

7.1.4.4 Summary

Infiltration control is considered the best available radionuclide control technology for tritium in the disposal vaults' exhaust. The alternative, condensation, offers no significant air quality benefit and possibly a significant environmental detriment because of the liquid waste that would be generated. In addition the energy and economic impacts of the condenser alternative are significant.

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APPENDIX A

LITERATURE SEARCH

LITERATURE SEARCH

The following data bases were searched for information pertinent to control systems for airborne releases of tritium.

DOE Energy

This database is one of the world's largest sources of literature references on energy and related topics, containing over 2,000,000 records. It covers journal articles, report literature, conference papers, books, patents, dissertations, and translations. DOE Energy covers the years 1974 to the present and is updated biweekly. It is maintained by the Department of Energy.

Energyline

Energyline is the online version of Energy Information Abstracts and also includes 8,000 energy and environment-related records dating back to 1971 from the Energy Index. Its coverage includes books, journals, congressional committee reports, conference proceedings, speeches, and statistics. The database contains 66,000 records and is updated monthly.

Enviroline

Enviroline covers more than 5,000 international primary and secondary source publications reporting on all aspects of the environment. Included are such fields as technology, biology, economics, geology, and chemistry as they relate to environmental issues. It covers the years from 1971 to the present, contains 131,250 records, and is updated monthly.

National Technical Information Service

The NTIS database contains more than 1.3 million records of government-sponsored research, development, engineering, and analytical reports prepared by Federal agencies, contractors, and grantees. Coverage is from 1964 to the present, and NTIS is updated biweekly. All of the reports cited in this database are unclassified and access is unlimited.

Pollution Abstracts

This database is a leading resource for references to environmental literature on pollution, its sources, and its control. Its 142,550 records, which are updated monthly, cover air pollution, environmental quality, radiation, solid waste, water pollution, pesticides, and noise pollution.

	Pertinent Literature	Database Source
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APPENDIX B

AIR POLLUTION CONTROL EQUIPMENT

ALTERNATIVE CONTROL EQUIPMENT

Control Technology

High Efficiency Particulate Air (HEPA) Filter

Pollutants Controlled

Particulate Matter

Process Description

A HEPA filter is a disposable, extended medium dry filter that has: 1) minimum particle removal efficiency of more than 99.97 percent for particles 0.3 um and larger: 2) maximum resistance, when clean, of 250 Pa (one inch w.g.) when operated at rated air flow capacity; and 3) rigid casing extending the full depth of the medium. The core of the HEPA is generally made by pleating a continuous web of fiber glass paper back and forth over corrugated separators that add strength to the core and provide air passages between the pleats. The core is then sealed in a wood or steel casing with an elastomeric sealant. The filter paper is made of very fine (submicron) glass fibers in a matrix of larger (1 to 4 micron) fibers and held together with an organic binder. Increased particle removal can be attained by using HEPA filters in series.

Current Applications

Filtration for clean room environments
Nuclear industry ventilation systems

Design Characteristics

Efficiencies of at least 99.97 percent for 0.3 micron or larger particles
Relatively low pressure drop (one inch w.g. new, 4 inches w.g. at replacement)

System Advantages

Extremely high efficiency
Simple design; no moving parts

System Disadvantages

Spent filters are solid waste
Must be kept dry to avoid fouling
Filter media are somewhat fragile

ALTERNATIVE CONTROL EQUIPMENT

Control Technology

Deep Bed Sand Filter

Pollutants Controlled

Particulate Matter

Process Description

Sand filters are deep (several feet) beds of rock, gravel, and sand constructed in layers that are graded with a 2 to 1 variation in granule size from layer to layer. Gas flows upward through the bed, with the granules decreasing in size in the direction of flow. A top layer of moderately coarser sand is added to prevent fluidization. Below the sand bed are hollow tiles that distribute the gas evenly through the bed. In theory, the larger granules remove most of the large particles and particulate mass, while the layers of finer sands provide high efficiency removal.

Current Application

Radiochemical processing facility ventilation systems

Design Characteristics

Removal efficiency reported to be 99.95 percent for 0.3 micron particles
Pressure drop of a 7 layer, 3-inch to 50-mesh filter is 7 to 11 inches w.g.

System Advantages

Low maintenance
Fire resistant
High heat capacity
Can accommodate large fluctuations in gas flow
Inert to chemical attack

System Disadvantages

Spent sands are solid waste
High initial cost
High pressure drop
Large space requirement

ALTERNATIVE CONTROL EQUIPMENT

Control Technology

Deep Bed Glass Fiber Filter

Pollutants Controlled

Particulate Matter

Process Description

Deep bed glass fiber filters are deep (8 to 84 inches) beds of compacted fiberglass insulating wool contained in stainless steel boxes that have opaque sides and perforated screens at the top and bottom. Different packing densities are used for each stage of the deep bed filter, with the low density packing stage at the gas inlet and the high density packing stage at the exit. Gas flows upward through the layers of fiber. The fibers used must have sufficient curl to resist matting when packed together; matting can cause pressure drops even at low airflows.

Current Applications

Radiochemical processing facility ventilation systems

Design Characteristics

Efficiencies of around 99.9 percent, which is less than a deep bed sand filter.

Pressure drop with a clean filter is 1.5 inches w.g.; with a spent filter, 8 inches w.g.

System Advantages

Predictable physical characteristics
Simple design

System Disadvantages

Lower particle collection efficiency than sand filters
Relatively high pressure drop
Spent filters are solid waste

ALTERNATIVE CONTROL EQUIPMENT

Control Technology

Prefilter (Roughing filter)

Pollutants Controlled

Particulate Matter

Process Description

Prefilters are classified as either low (Group I), moderate (Group II), or high (Group III) efficiency filters. Group I panel filters are shallow tray-like assemblies of coarse fibers or crimped metal mesh enclosed in a steel or cardboard casing. Groups II and III filters are extended-medium, dry units. The medium is pleated or in a bag shape to increase surface area. Group II filters are effective in removing particles of 5 microns or larger, while Group III filters can remove smaller particles.

Current Applications

Air filtering systems
Heating and ventilation systems

Design Characteristics

Effective in removing large (greater than 5 micron) particles
Pressure drop approximately 4 inches w.g.

System Advantages

Low initial and operating costs
Simple design
Easily replaced
High dust loading capacity

System Disadvantages

Relatively high pressure drop
Spent filters are solid waste

ALTERNATIVE CONTROL EQUIPMENT

Control Technology

High Efficiency Mist Eliminator (HEME)

Pollutants Controlled

Fine mists, Particulate matter, Aerosols

Process Description

HEMEs are regenerable deep bed fiber filters configured in an annular shape to remove submicron aerosols. Gas flows from the outside to the inner hollow core; clean gas exits at the top. Collected liquid exits at the sealed bottom through a drain pipe. Various fibers and other materials of construction can be selected for their resistance to gas constituents. HEMEs also can be operated wet to allow simultaneous removal of both liquid and solid aerosols. Soluble particles become part of the liquid film and drop to the drain, while the insoluble particles lodge on the fiber and become physically bonded. Continuous or intermittent water spraying of the filter elements has been used to wash down accumulated debris, which extends the filter's service life. However, water soluble compounds can migrate through the filter and become re-entrained.

Current Applications

Acid and caustic mist removal
Radiochemical plants

Design Characteristics

100 percent removals of particles larger than 3 microns
99.5 percent removal of particles smaller than 3 microns
Pressure drops up to 25 inches w.g.

System Advantages

High efficiencies
Simple design
Life can be extended by backwashing filter elements

System Disadvantages

High pressure drop
Produces liquid and solid waste
Sensitive to process variations
Relatively large space requirements
Fouls easily requiring regular cleaning which produces more liquid waste

ALTERNATIVE CONTROL EQUIPMENT

Control Technology

Fabric Filter (Baghouse)

Pollutants Controlled

Particulate Matter

Process Description

Fabric is arranged in envelope or tubular shapes and the entire arrangement is called a baghouse. The air stream passes through the fabric and is filtered. The filtering process, especially for submicron particles is not simple sieving but is obtained by the buildup of a mat of material on the dirty side of the fabric initially by interception, impingement, diffusion and electrostatic attraction. As dust is collected on the fabric, resistance to flow increases and the fabric must periodically be reconditioned by shaking, vibrating, reverse-jet or reverse-flow collapse. Woven cotton or wool is frequently used as the fabric, although a wide range of materials is possible.

Current Application

Used to control atmospheric emissions from a variety of sources including uranium machining dust, particulate matter from uranium chemical salvage and uranium metal casting operations, and particulate emissions from a uranium incinerator. Widespread application outside the radiochemical industry including coal boilers, carbon black processes, chemical production and woodworking operations.

Design Characteristics

Removal efficiency reported to be 99.9 percent for 1 micron and larger particles
Pressure drop of 3 to 8 inches w.g.

System Advantages

Can accommodate large fluctuations in gas flow
Can accommodate large changes in flue gas composition

System Disadvantages

Used fabric is a solid waste
Large space requirements
Low fire resistance
Subject to chemical attack (but can be controlled with fabric selection)

ALTERNATIVE CONTROL EQUIPMENT

Control Technology

Electrostatic Precipitators (ESP)

Pollutants Controlled

Particulate Matter

Process Description

The ESP relies on the ability to impart a negative charge to particles in the gas stream causing them to move and adhere to the grounded positively charged collector plates. Removal of the collected material is accomplished by rapping or vibrating the element continuously or at a predetermined intervals.

Current Application

Widespread application in industry to control particulate matter from steam boilers, kraft pulp mills, cement kilns, asphalt saturators, glass furnaces, and numerous others.

Design Characteristics

High removal efficiencies in excess of 99% can be obtained
Low pressure drops through systems (seldom exceed 125 Pa)
No theoretical lower limit for size of particle that can be collected.

System Advantages

High efficiency
Low pressure drop
Can handle large exhaust flows

System Disadvantages

High cost
Efficiency greatly affected by particle resistivity
Potentially high space requirements
Personnel must be safeguarded from high voltage

ALTERNATIVE CONTROL EQUIPMENT

Control Technology

Adsorption

Pollutants Controlled

Tritiated Water

Process Description

The tritiated water vapor is passed through a desiccant or molecular sieve which selectively retains water.

Current Application

Remove tritiated water from laboratory ventilation system. Initial form of the pollutant is molecular tritium which is converted in a catalytic reactor to tritiated water.

Design Characteristics

The removal efficiencies depend both on the construction of the units (bed depth, particle size) and operating parameters (flow rate, temperature). Control efficiencies in excess of 99 percent are achievable.

System Advantages

Simple, well established technology
No moving parts

System Disadvantages

Collects non-tritiated water that is present
Creates a solid waste or, if adsorption media is regenerated, a liquid waste.
High power requirements

ALTERNATIVE CONTROL EQUIPMENT

Control Technology

Condensation

Pollutants Controlled

Tritiated water

Process Description

In a two-component vapor (i.e., air and water vapor) where one component can be considered non-condensible, condensation occurs when the partial pressure of the condensible component equals the component's vapor pressure. At a fixed pressure, the temperature of the gaseous mixture may be reduced until the vapor pressure of the condensible component equals its partial pressure. As the temperature is further reduced, condensation continues such that the partial pressure is always equal to the vapor pressure.

Current Application

Condensation is being used for the recovery of gasoline vapors at bulk gasoline terminals. Condensation has also been used in controlling organic emissions from petroleum refining and petrochemical manufacturing, dry-cleaning, degreasing, and tar dipping.

Design Characteristics

The removal efficiencies depend both on the temperature of the air and its humidity as well as design of the system. Control efficiencies in excess of 95 percent are achievable but highly dependent upon the characteristics of the gas stream being treated.

System Advantages

Well established technology

System Disadvantages

High power requirements
Creates liquid waste